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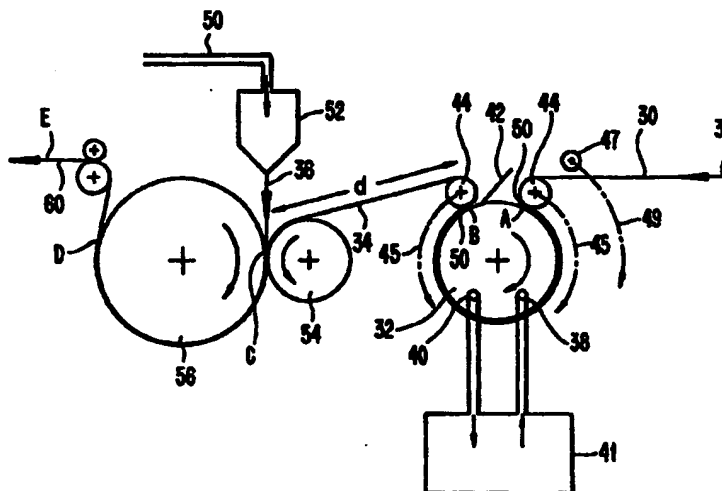
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(57) Abstract

The disclosure relates to a process for manufacturing carpet, an apparatus used in a carpet manufacturing process and carpet made by the process and with the apparatus. The process includes providing a carpet base having a primary backing penetrated by yarn, applying heat to the underside of the base, extruding a heated sheet of polymer and continuously contacting the heated extruded sheet of polymer with the base thereby integrally fusing the base to the extruded sheet. The apparatus includes a source of carpet precursor (30), a heated source for heating the underside of the carpet (32), an extruder (52) and a casting roll (56) against which the extruded sheet (36) and heated carpet (34) are pressed.

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IMPROVEMENTS IN CARPET MAKING

The contents of Serial No. 07/833,093 filed February 10, 1992, now U.S. Patent No. 5,240,530, is hereby incorporated by reference.

5

FIELD OF THE DISCLOSURE

The disclosure relates to methods for making carpets, and in particular, improved techniques for securing face yarn to one or more backing layers, including use of an extruded sheet. The disclosure also relates to apparatus for manufacturing carpet in accordance with these methods, and to the improved carpet produced thereby.

15

BACKGROUND

Most carpets are composite structures in which the face fiber forming the pile, i.e., the surface of the carpet, penetrates at least one backing layer. The base portions of the facing yarn extend through the backing and are exposed on the bottom surface of the primary backing. Such carpets may be cut pile or loop pile. Aspects of the present invention are also applicable to woven or knitted carpets such as Berber carpets and certain sports surfaces.

The basic manufacturing approach to the commercial production of tufted carpeting is to start with a woven scrim or primary carpet backing and to feed this into a tufting machine or a loom. The carpet face fiber is needled through and embedded in the primary carpet backing thus forming a carpet precursor or base sometimes called griegge goods. Upstanding loops on the upper side of the carpet may be cut to produce cut pile carpet. Yarn loops or knots are usually exposed on the underside of the griegge goods.

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Griege goods are typically backed with an adhesive coating in order to secure the face yarn to the primary backing. Low cost carpet often receives only a latex adhesive coating as the backing. This type of carpet is widely used in boats and is called marine backed carpet. Typically, the marine backed carpets are backed with a latex adhesive coating that is water and/or mildew resistant. Higher cost carpet often receives both a latex adhesive coating and a secondary backing.

The face fiber or yarn used in forming the pile of a tufted carpet is typically made of any one of a number of types of fiber, e.g., nylon, acrylics, polypropylene, polyethylene, polyamides, polyesters, wool, cotton, rayon and the like. Face yarns used in carpet include bulk continuous filament (bcf) yarns which are made up of tens or hundreds of individual fibers. Fibrillated polypropylene grass yarn is also often used as a face yarn.

Primary backings for tufted pile carpets are typically woven or non-woven fabrics made of one or more natural or synthetic fibers or yarns, such as jute, wool, polypropylene, polyethylene, polyamides, polyesters, nylon and rayon. Films of synthetic materials, such as polypropylene, polyethylene and ethylene-propylene copolymers may also be used to form the primary backing. Likewise, secondary backings for tufted pile carpets are typically woven or non-woven fabrics made of one or more natural or synthetic fibers or yarns.

The application of the latex adhesive involves coating the bottom surface of the thus formed grieger goods with a latex polymer binder such as a styrene-butadiene copolymer. The coated grieger goods are then passed through an oven to dry the latex adhesive coating. In this way the face fibers are attached to the primary backing by the latex binder.

It is known in the art to subject the back of grieger goods to a gas flame to reduce the bulk of the protruding

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fac yarn, particularly in greige goods with large knots, in order to reduce the amount of latex adhesive necessary to provide a smooth, well-covered surface. It is also known to apply pressure and low level heat (i.e. below yarn melting temperature) to flatten the knots prior to the application of the latex adhesive.

If desired, a secondary backing may be bonded to the undersurface of the primary backing. To produce tufted carpets with a secondary backing, the bottom surface of the grieger goods is coated with a latex polymer binder. Thus, the secondary backing is applied to the coated bottom surface and the resulting structure is passed through an oven to dry the latex adhesive coating to bond the secondary backing to the grieger goods.

The above-described methods have disadvantages in that they require a drying step and thus an oven to dry the latex polymer binder. The drying step increases the cost of the carpet and limits production speed. Furthermore, it has been reported that latex adhesive compositions generate gases that may be the cause of headaches, watery eyes, breathing difficulties and nausea, especially when used in tightly sealed buildings. See Herligy, The Carpet & Rug Industry, October 1990. In addition, overheating of the carpet may occur during drying of the latex which in turn may affect the shade of the carpet.

Consequently, carpet manufacturers have been attempting to develop a new approach for the preparation of tufted carpets. One new approach is the preparation of tufted carpets with a hot-melt adhesive composition instead of a latex composition.

Hot-melt adhesives are amorphous polymers that soften and flow sufficiently to wet and penetrate the backing surfaces and tuft stitches of carpets upon application of sufficient heat. Furthermore, hot-melt adhesives tend to adhere to the backing surfaces and/or tuft stitches. That is, hot-melt adhesives stick to backing surfaces and tuft

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stitches.

By the use of hot-melt adhesive, the necessity of drying the composition after application is eliminated and further, when a secondary backing material is desired, it can be applied directly after the hot-melt composition is applied with no necessity for a drying step.

Both latex adhesive based carpet and hot-melt adhesive based carpet have the disadvantage that they are not readily recyclable. Thus, large quantities of carpet trimmings and scrap produced during the manufacture of carpet and used carpet are sent to landfills. Consequently, carpet manufacturers spend a substantial sum on landfill costs. Such carpets are not recyclable after their useful life.

Thus, conventional carpet and carpet manufacturing processes have inherent problems. Specifically, the adhesives used to adhere the tufts of face fiber to the primary backing and to adhere the secondary backing to the primary backing include compositions which require lengthy drying times thus slowing down the manufacturing process. In addition, the latex compositions may produce noxious gases which create health hazards. Likewise, many of the hot-melt compositions conventionally employed in the manufacture of carpet do not result in reproducible consistency regarding scrim bonds, tuft pull strength and fuzz resistance. Finally, the use of conventional latex adhesives and hot-melt adhesives prevent carpet from being efficiently recycled.

In the parent application, there is disclosed certain methods for producing carpet. According to the teachings of that application, a thermoplastic polymer sheet may be extruded into contact with griegge goods to integrally fuse the primary backing, face yarn and extruded sheet. In a preferred embodiment the yarn, backings and extruded sheet are made of the same polymer, e.g. polypropylene. Cut pile carpet is presented as exemplifying the use of the methods.

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Trimnings, scrap and used carpet made in this fashion may be readily recycled because of their homogeneous chemical composition. No latex or adhesive application is required. Nor is a backing step required, though it may also be employed in some products.

Use of the techniques of the parent application have been found to present special problems when employed in the manufacture of loop pile carpet made with multi-fiber face yarns. In use, the closed loops of the carpets can be readily caught or snagged, for example by passing traffic. As a result long fibers may be pulled from the yarn leaving an undesirable surface fuzz after periods of wear.

It is known to test conventional carpets for integrity by the so-called VELCRO® test. VELCRO is a registered trademark for the well-known hook and loop fastening material. In this test a roller coated with VELCRO® hook material is rolled repeatedly over the loop pile of the carpet, for example ten times. The carpet is then inspected for protruding fibers or fuzz.

It is known that latex adhesives, if properly applied, can provide sufficient binding of carpet fibers to permit manufacture of loop pile carpets which can pass the VELCRO® test. It is important that any proposal to replace the use of conventional adhesives be likewise capable of producing a carpet in which the face yarn or fibers are securely attached to the carpet, and, in particular, capable of producing loop pile carpet made with bcf face yarn which can pass the VELCRO® test.

The present application includes disclosure of improved techniques for manufacturing carpet while retaining various advantages of the methods initially disclosed in the parent application.

SUMMARY OF THE DISCLOSURE AND OBJECTS

The present disclosure relates to a method and

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apparatus for producing a carpet and the resulting carpet product. In preferred embodiments, the carpet may be readily recycled to provide input feedstock for the making of new carpet.

5 In accordance with preferred embodiments of the present invention a method is disclosed for making carpet in which a tufted, woven or knitted carpet precursor is provided. In a preferred embodiment the carpet precursor or carpet base comprises a primary backing penetrated by
10 face yarn so that first portions of the yarn protrude from an upper side of the backing to form the pile of the carpet and so that knots or back loops of the yarn are exposed on the underside of the carpet base. Heat is applied to the underside of the carpet base. Advantageously this may be
15 accomplished by pressing the carpet base against a heated roller whose surface is maintained at a temperature near or above the melting temperature of the face yarn or backing. A heated sheet of polymer may then be extruded onto the underside of the carpet base, thereby integrally fusing the
20 yarn knots or back loops and the extruded sheet to form a carpet product. Scraps, trimmings and used carpet made by this process may be recycled as polymer feedstock for extrusion in making new carpet.

It is an object of the present invention to provide an
25 improved process for manufacturing carpets made of thermoplastic polymers.

It is another object of the present invention to provide a process for manufacturing a recyclable carpet made entirely of thermoplastic polymers.

30 It is another object of the present invention to provide a process for manufacturing a carpet made from thermoplastic polymers which satisfies commercial requirements relating to resistance to fuzzing, yarn integrity, tuft binding and lamination strength.

35 The present disclosure also relates to carpet making machinery. In one embodiment carpet precursor is supplied

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to an arrangement of rollers including a fluid heated roller which is pressed against the underside of the carpet precursor. An extruder directly extrudes a hot thermoplastic sheet onto the heated underside of the carpet precursor. The laminate so formed is pressed against a cooled casting roll.

In an alternate embodiment of the present invention, a preformed sheet of thermoplastic polymer is simultaneously heated and laminated with carpet precursor in an apparatus including a continuous moving surface or belt. The belt is differentially heated so that it is relatively hot at the location where it first contacts the polymer sheet. The belt is moved and cooled so that it readily separates from the underside of the carpet after the carpet precursor and polymer sheet have been integrally fused.

Accordingly, it is an object of the present invention to provide machinery for producing a carpet from a carpet precursor fused with a polymer sheet.

The present disclosure also relates to certain novel carpet products. A preferred carpet is made entirely of the same isotactic or crystalline thermoplastic polymer, e.g. polypropylene. The face yarn is a bulk continuous filament yarn with multiple fibers. The yarn is tufted in a primary backing and laminated with a polymer sheet so that the yarn back loops, primary backing and sheet are integrally fused and so that substantially all the yarn fibers are secured in place.

It is an object of the present invention to provide a carpet made entirely of isotactic thermoplastic polymer in which the face yarn is securely fused to its backing.

It is another object of the present invention to provide a loop pile carpet made of recyclable thermoplastic polymer which is resistant to fuzzing when the pile is abraded.

It is another object of the present invention to provide a carpet made from isotactic thermoplastic polymer

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which has satisfactory tuft binding and lamination strength.

These and other objects and features will be apparent from the detailed descriptive material which follows.

5

BRIEF DESCRIPTION OF THE DRAWINGS

10 Figure 1 is a cross-sectional view of a carpet being manufactured in accordance with a preferred embodiment of the present invention;

Figure 2a is a side schematic view of an apparatus used in the making of carpet, employing a heated roller;

Figure 2b is a pictorial view of an apparatus of the type described generally in connection with Figure 2a;

15 Figure 3 is a graph illustrating the estimated temperatures of carpet components as a function of time for the apparatus of Figures 2;

Figure 4 is a side schematic view of an apparatus used in the making of carpet, employing a heated plate;

20 Figure 5 is a side schematic view of an apparatus used in making carpet employing a continuous, temperature-controlled surface;

Figures 6a is a cross-sectional view of a cut pile carpet precursor;

25 Figure 6b is a cross-sectional view of a cut pile carpet made in accordance with the teachings of the present invention;

Figure 7a is a cross-sectional view of a carpet precursor for a loop pile carpet;

30 Figure 7b is a cross-sectional view of a loop pile carpet made in accordance with the teachings of the present invention; and

35 Figure 7c is a cross-sectional view of a loop pile carpet with secondary backing made in accordance with the teachings of the present invention.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to the present invention, a thermoplastic polymer sheet is laminated with a carpet precursor to form a carpet product with desirable physical properties. Generally, the carpet precursor is made of a face yarn which interpenetrates a backing or grid defining the plane of the finished carpet. The carpet precursor may be woven or knitted. In preferred embodiments, face yarn is tufted in a primary backing. The thermoplastic polymer sheet is laminated to the underside of the carpet precursor. A carpet product with excellent physical properties, which is capable of being recycled, may be made using the techniques and apparatus described as follows.

Figure 1 illustrates some of the features of a carpet product of a preferred embodiment of the present invention. A primary backing layer is designated by the numeral 10. Face yarn is tufted in the primary backing forming a yarn pile 12 on the upper side of the carpet and back loops or knots 14. The tufted primary backing 16 is referred to here as the carpet precursor, carpet base or grieg goods. On the left-hand side of Figure 1, the carpet face yarn is loosely secured to the backing 10 by the tufting process to a degree sufficient for movement of the precursor for further processing, but the precursor is not sufficiently mechanically stable for use as a finished carpet.

The precursor is laminated with a polymer sheet 18 to form the carpet product 20. Advantageously, the sheet is an extruded sheet of thermoplastic polymer. The carpet precursor is integrally fused with it.

IMPROVED METHODS AND APPARATUS FOR CARPET MANUFACTURE

With continued reference to Figure 1, an improved method of making a carpet product is generally illustrated. Heat is applied to the underside of the carpet precursor at

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location 22 sufficient to heat the underside to above the melting point of the constituent thermoplastic polymer. A heated sheet of thermoplastic polymer 18 is brought in contact with the heated carpet precursor at location 24
5 whereby the laminated carpet product 20 is produced. The carpet product may either be the finished carpet or subjected to further processing, e.g. application of additional backings.

An apparatus for producing a carpet product is
10 illustrated in Figures 2a and 2b. Carpet precursor or griage goods 30 are supplied at location 31 with the carpet pile facing downwardly. The carpet precursor is placed in contact with a heated roller 32, whereby the underside of
15 the back loop or knots of the carpet precursor which may be partially melted. The heated carpet precursor 34 travels downstream in the apparatus for lamination with a thermoplastic polymer sheet 36.

The heated roller 32 may advantageously be a fluid or
20 oil heated roller although other means may be employed to uniformly heat the surface of the roller such as electrical resistance elements. When heated fluid is employed, the fluid enters the system at 38 (while shown in Figure 2a off-center, the fluid inlet is typically at the
25 center of the roll), is circulated in the roller 32 and exits at 40 (while shown in Figure 2a off-center, the fluid outlet is typically at the center of the roll). The oil is reheated and recirculated in a closed loop system designated generally by numeral 41. Advantageously, the
30 system is operated to maintain the surface of the roller 32 at a uniform temperature across the width of the roller. The optimum surface temperature of the roller is dependent on a number of variables including the structure and composition of the carpet precursor, line speed, roller
35 pressure and the area of the contact between the roller 32 and the carpet precursor. In the system illustrated in

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Figure 2, the roller 32 is 5.9 inches in diameter. The surface of the roller may be maintained between 330°F and 650°F or even higher and preferably between 400°F and 500°F. At a line speed of about 10 feet per minute, the preferred roller surface temperature was about 400 to 450°F using certain common carpet precursors as described in greater detail in the examples below.

The roller 32 may be provided with a surface or coating which resists sticking. In the system illustrated in Figure 2, the roller 32 is wrapped with teflon tape. A doctor blade 42 may be provided to remove built-up polymer melted from the underside of the carpet precursor.

Water cooled nip roll 44 may be provided which, together with the tension in the running carpet precursor, hold the underside of the carpet precursor against the heated roller. With reference to Figure 2b, which shows some additional aspects of the apparatus of Figure 2a in perspective view, the heated roller and auxiliary rollers are designated 32' and 44', respectively. The auxiliary rollers 44' are rotatably mounted to a pivoting bar assembly 46. The pressure of the carpet precursor against the heated roller is controlled by applying pressure to the pivoting bar assembly 46 by means of hydraulic actuators 48. The pressure at nips 50 and 50' have been desirably controlled to provide a contact pressure at a tangential point between the nip rolls 50 and 50' and chill roll 32 of between 1 and 4 pounds per linear inch of width with a gap setting between the respective rolls prior to introducing the carpet precursor of between zero and one inch. The contact pressure and gap setting will depend upon the thickness and density of the carpet precursor. In the apparatus of Figure 2, the hydraulic pressure may typically be set at 60 to 80 pounds per square inch to obtain the desired contact pressure at the recited gap setting.

Referring once more to Figure 2a, the rollers 44 may be mounted so that their axes of rotation can be

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selectively positioned along lines 45. An additional roller 47 may be provided, whose axis of rotation may be selectively positioned along line 49. During line start-up, rollers 44 and 47 may be moved downwardly so that the path of the greige goods 30 is located out of contact with the heated roller 32, to thereby prevent overheating of the greige goods as it is being threaded into the line. In addition, during operation, the location of rollers 44 along lines 45 may be adjusted to vary the heat input into the greige goods. Thus, the heated roller temperature can be maintained constant and the wrap angle (i.e. residence time) of the greige goods adjusted for line parameter variations such as greige goods weight.

As shown in Figure 2a, the heated carpet precursor 34 travels a short distance "d" to be laminated with the polymer sheet 36. Advantageously, this distance is as short as possible to minimize heat loss from the carpet precursor. The heated carpet precursor 34 may contact the heated polymer sheet directly extruded downwardly onto the underside of the carpet precursor. The sheet is formed by forcing a polymer feedstock 50 through an extrusion die 52. In examples discussed below, the extrusion die temperature is about 510°F. It is desirable that the extruded sheet be above its melting temperature when it contacts the carpet precursor, advantageously 100°F or more above the melting temperature.

The extruded sheet and carpet precursor together pass between nip roll 54 and casting or chill roll 56. As shown in Figure 2b, the nip roller 54' may be rotatably mounted on parallel pivoting arms 58. The nip roller and pivoting arms exert a pressure against the upper side of the carpet precursor which consequently presses the extruded sheet against the casting roller 56'. A contact pressure at a tangential point between the nip roller 54 and the chill roller 56 of between 1 and 4 pounds per linear inch of width with a gap setting between the respective rolls prior

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to introducing the carpet precursor of between zero and one inch has been desirably utilized. The contact pressure and gap setting will depend upon the thickness and density of the carpet precursor. Advantageously, the casting roller is maintained at a controlled temperature. In the examples discussed below, that temperature is 130°F.

A carpet product 60 is produced which may be subjected to additional processing. Optionally a secondary woven backing or co-extruded backing (not shown) may be simultaneously laminated to the extruded sheet 36 at the casting roll 56.

In order to control shrinking of the carpet precursor or carpet product, a tenter frame (not shown) may be employed during the preheating and lamination operations or thereafter.

Various polymers have been extruded or laminated onto carpet precursors. Trials have been conducted using polypropylene homopolymer (prime virgin 5 mils), polypropylene copolymer (recycled from shrink film), polypropylene homopolymer (recycled from fiber), and thermoplastic elastomer polypropylene blend (50/50 blend). In all the trials, the extruded sheet exhibited good bonding strength to the back of the carpet. The griage goods used in the trials included a polypropylene primary backing with polypropylene face fiber and a polypropylene primary backing with nylon face fiber. In addition, certain carpet trials included a secondary backing of woven polypropylene. The secondary backing was found to exhibit good adhesion with all the polymer types listed.

The extrusion trials were conducted with a 1.5 inch diameter, 24:1 (barrel length to diameter ratio), Sterling extruder. The extruder had a 20 horsepower DC drive and a single stage screw. The extruder was equipped with three heating zones, a screen pack collar and a pressure gauge. Speed was controlled by a variable resistor dial and a tachometer was connected to an RPM dial for speed

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indication. Typical extruder temperatures range from 340°F to 580°F and pressures from 1000-3000 psi. Typical die melt temperatures range from 450-580°F.

5 The apparatus used in the examples described below included a heated roller of the type shown in Figure 2. In that apparatus, the die width was 12 inches. The molten polymer from the die was deposited on a water cooled casting roll (7.9 inch diameter, 13 inch width). Water was passed through helical passages within the casting roll at high velocity to cool the casting roll as required. The 10 nip roll was 3 inches in diameter. The casting roll assembly was driven by an eddy current clutch and a 1.5 horsepower motor.

While speeds of 10 feet per minute were actually used 15 in the examples described below, it is contemplated that higher speeds would be used in commercial production. In particular, since there is no drying step, speeds of 100 to 300 feet per minute appear possible. Carpet widths of 12 to 15 feet may be produced. Such speeds and widths require 20 appropriate material and handling capability to move large rolls in and out of the process quickly. Thus, in contrast to conventional processes, the factor limiting line speed may be material handling and not the conventional adhesive drying step, which is eliminated in the practice of the 25 present method.

Figure 3 presents a calculated temperature profile for the apparatus of Figure 2 in graphical form. Temperature is represented on the vertical axis; time/position is represented on the horizontal axis. Trace 70 represents 30 the back loop temperature at various points in the process designated by letters A through E which correspond to similarly labeled locations in the apparatus of Figure 2(a). Trace 72 represents the carpet face temperature at the points A through E of Figure 2(a). The dotted line 74 35 represents the melting temperature of the back loop yarn. Figure 3 illustrates a temperature profile in which the

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back loops are maintained above their melting temperature, while the temperature of the carpet face always remains below the melting temperature.

Figure 4 is a schematic side view of an alternative embodiment of the present invention. The underside of a carpet precursor 80 is passed in contact with an electrically heated plate 82. The carpet precursor 80 may be pressed between the electrically heated plate 82 and a second plate 84 whose temperature is not controlled. Successful trials of the apparatus have been run where the surface temperature of the plate 84 was set at 600°F. Alternatively, a radiant heater (not shown) may be substituted for the heated plate 82.

With continuing reference to Figure 4, heated carpet precursor 86 is drawn to the nip 87 formed between nip roller 88 and casting roller 90. A polymer film 92 is extruded directly onto the underside of the heated carpet precursor from extrusion die 94. Casting roll temperatures between 80 and 120°F have been employed. Pressure of between 50 to 70 psi at the nip 87 have been employed.

Temperature variations across the heated plate 82 have been observed to produce variation across the width of the carpet product. Cool areas produce regions in loop pile bcf carpet which fail the VELCRO® test. Hot areas produce regions of apparent excess shrinkage and face yarn damage. In addition, the hot areas may deposit excessive melted polymer onto the heated plate.

Figure 5 is a schematic side view of another embodiment of the present invention. In Figure 5 a carpet precursor 100 is supplied to the apparatus, pile side down. A sheet 102 of polymer is also supplied to the apparatus. The sheet 102 may either be freshly extruded in a manner similar to that described above, or it may be formed at a different time and/or location and supplied from a feed roll.

The apparatus of Figure 5 includes a first

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5 differentially heated and cooled surface 104. The surface functions both as a heated surface for integrally fusing the polymer sheet 102 to the carpet precursor 100 and as a casting surface for forming and cooling the underside of the carpet product.

10 In preferred embodiments of the present invention the surface 104 is a continuous belt, which travels around heated cylinder 106 and cooled cylinder 108. Stationery, heating and cooling units 110 and 112 respectively, may also be provided to adjust the temperature profile around the path of travel of the belt 104.

15 In operation, the belt is differentially heated so that it is relatively hot at location 114 where it first contacts the polymer sheet 102. At a downstream location 116 the heated polymer sheet contacts the carpet precursor, the combination of which is moved and cooled as the belt travels from left to right in Figure 5.

20 A lower continuous belt system 118 may be provided for applying pressure to the upper side of the carpet product. An upper surface 120 of the lower belt may be oriented at an angle with respect to the upper belt as illustrated in order to gradually increase the pressure exerted on the carpet product. The temperature of the lower belt 118 may also be controlled in a manner similar to belt 104, albeit at lower temperatures.

25 At location 122 the carpet product and belt are sufficiently cool that the carpet product readily separates from the belt without leaving significant amounts of melted polymer (preferably no melted polymer) on the belt 104. 30 From this location the carpet product travels downstream in the production line.

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CARPET PRODUCTS

Figure 1 illustrates a preferred embodiment of the present invention: a carpet product including a face yarn and a backing material integrally fused with an extruded sheet of polymer.

More specifically, preferred embodiments of the carpet may comprise a primary backing, face yarn protruding from a top surface of the primary backing, and an extruded sheet of a thermoplastic polyolefin polymer integrally fused to back loops or knots of the face yarn and/or to the bottom surface of the primary backing. The fused portions of the carpet product are the result of a heat bond between the carpet precursor and the extruded sheet during the manufacturing process. Likewise, there may be a mechanical bond between the primary backing, the extruded sheet and face yarn, resulting from the thermoplastic polyolefin polymer flowing between and around the fibers making up the primary backing, and the face yarn.

The carpet product of the present invention may also include one or more secondary backing layers integrally fused to the carpet precursor by an extruded polymer sheet.

Various materials generally suitable for the carpet products of the claimed invention are disclosed in parent U.S. Patent No. 5,288,349, incorporated by reference herein.

In one preferred embodiment, the face yarn, backings and extruded sheet comprise the same thermoplastic polymer. Preferably the thermoplastic polymer is an isotactic polyolefin polymer, especially an isotactic polypropylene homopolymer, random impact or block copolymer or terpolymer.

In another embodiment the backings and extruded sheet are formed of one polymer and the face yarn is formed of a different polymer. For example, the backing and extruded sheet are formed of an isotactic polyolefin polymer and the

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face yarn is formed of nylon or polyester, or of natural materials such as cotton or wool. In other embodiments, some or all of the backing may be formed from such materials. It is preferred, however, to use a polymer with melting points similar to that of the extruded sheet to facilitate integral fusing with the extruded sheet.

In some carpets the bottom layer (either the extruded sheet or secondary backing) may be formed from a blend of thermoplastic polyolefin polymer and thermoplastic elastomer to provide some properties of the elastomer such as flexibility, non-skid character and other properties similar to rubber.

The primary backing of the carpet product may include any synthetic resin that will integrally fuse with the extruded sheet and may be, for example, a woven or non-woven fabric, a film or a web. Preferably, the primary backing is made of a thermoplastic polyolefin polymer, copolymer or terpolymer.

The secondary backing material, if applied, may preferably include any synthetic resin that will integrally fuse with the extruded sheet. Advantageously, the secondary backing will comprise the same thermoplastic polyolefin polymer, copolymer or terpolymer as the primary backing. Optionally, the secondary backing for the carpets of the present disclosure is a woven or non-woven fabric. Likewise, the secondary backing may be an open weave or leno weave, i.e., tape yarn in the warp direction and spun staple fiber in the fill direction. However, the open weave or spun staple warp is not necessary to obtain a suitable bond as may be required with use of a latex adhesive.

The extruded sheet may be formed from a substantially crystalline or isotactic, thermoplastic polyolefin polymer, copolymer or terpolymer. A preferred thermoplastic polyolefin polymer is isotactic polypropylene homopolymer. The polymer may be a commercial isotactic polypropylene

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which is polymerized to a 90 to 98% isotactic content, with the remaining polymer being in the randomly ordered atactic configuration. The degree of isotacticity can be further enhanced by post-reaction solvent extraction of the atactic polypropylene. Both commercial and purified grades of isotactic polypropylene are suitable for use in the extruded sheet of the present invention.

Isotactic polypropylene is suitable for use in the extruded layer since it has a relatively specific melting point (about 330°F) and a relatively specific recrystallization point (about 300°F). Atactic or amorphous polypropylene has no specific melting or recrystallization point. Thus, amorphous polypropylene is difficult to integrally fuse to either the primary backing, face fibers, or secondary backing. Furthermore, the tensile strength of the isotactic polypropylene is approximately 28 to 40 times stronger than the tensile strength of the atactic polypropylene. Thus, the extruded sheet does not require the presence of atactic polyolefin to provide the requisite bond strength between the primary backing, tufts of face fiber or secondary backing. In addition, due to the tensile strength of the isotactic polyolefin, carpets with increased delamination strength may be made.

In addition to homopolymer, other classes of polypropylene are commercially available and may be suitable for use in the extruded sheet. These include polypropylene random copolymers, impact or block copolymers, and terpolymers.

The isotactic polypropylene or other crystalline olefin used in the extruded layer may be compounded with inert fillers by either extrusion compounding or mixing operations. Such fillers may include calcium carbonate, silicates, talc, calcium, glass fibers, carbon black and wood flour. Other fillers may be suitable.

The use of such fillers in the extrusion layer may

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range from about 0.1% to as high as about 50%. At the high levels, an exceedingly stiff board like material may be made that may be used, e.g., as a trunk liner, molded floor mat or a door panel in an automobile. Since addition of a
5 filler significantly alters the performance and process ability of the polymer, filled systems may be designed to satisfy a particular product need with minimum effect on other performance aspects.

It is desirable that, for some use applications, carpet made in accordance with the present invention pass
10 the "pill test" (ASTM D-2859) for fire resistance. Thus, in some applications where enhanced flame resistance is required, a fire-retardant may be added to the feedstock used to produce the extruded sheet.

15 Optionally, blends of polyolefins and thermoplastic elastomers may be used to make the extruded sheet or co-extruded layer. The thermoplastic elastomers (TPE's) are a diverse family of rubber-like materials that, unlike vulcanized rubbers, may be processed and recycled as
20 thermoplastics. However, the TPE's are not merely substitutes for thermosetting polymers, they may also replace or improve their properties. There are four general groups of TPE's that may be suitable for use in the present invention. The four general groups include
25 polyurethanes, copolyesters, styrenic block copolymers, and polyolefins. Blending the elastomer with the polyolefin polymer provides some of the properties of the elastomer at a lower cost. The compatibility is good for blends ranging from about 10 to 97% elastomer based on the total amount of
30 thermoplastic polymer and elastomer.

As a class, the TPE's may provide toughness, flexibility over a wide temperature range, and resistance to abrasion, weathering, and a variety of solvents and other chemicals. Thus, the properties of each of the
35 materials in the group may be tailored for use in the carpet of the present invention by polymerization methods,

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- blending, and incorporation of additives, fillers, and reinforcements to form carpets having enhanced abrasion, weathering and chemical resistance.
- Figures 6 and 7 illustrate, by way of example, two types of carpet products made in accordance with the teachings of the present invention. Figure 6 relates to a cut pile, grass carpet and Figure 7 relates to a loop pile carpet with optional secondary backing.
- Figure 6a depicts a carpet precursor 200 from which grass carpet is made. A woven primary backing 202 is interpenetrated by fibrillated isotactic polypropylene yarn 204. Cut yarn ends or tufts 206 form the pile of the carpet. The yarn is loosely secured in place by back loops 208 exposed on the underside of the carpet precursor. In this example the backing 202 is a woven fabric made of polypropylene.
- Figure 6b depicts a carpet product 210 made from the carpet precursor of Figure 6a. An extruded sheet 212 of polypropylene has been integrally fused to the carpet and portions of the backing 202 to the back loops 208 and the extruded sheet 212. Spaces between the back loops 208 depending on the penetration of the extruded sheet material into the primary backing during manufacture. In fact, the extruded sheet may more or less conform to the shape of the bottom surface of the primary backing. Thus, there may be little, if any, space between the extruded sheet and the primary backing. The underside 214 of the carpet product may be essentially flat due to the cooling contact made with the surface of the casting roller during processing. During manufacture the back loops 208 may be partially melted, so that individual fibrils of the yarn are integrally fused with each other and with the extruded sheet and primary backing 202. This action is believed to enhance the mechanical durability of the resulting carpet

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product.

Figur 7a depicts a carpet precursor 300 from which a level loop pile carpet is mad . A woven primary backing 302 is interpenetrated by a multi-fiber face yarn or bulk continuous filament (bcf) yarn 304. Such yarn may be a twisted array of, for example, 120 small denier fibers. Yarn loops or tufts 306 form the pile of the carpet. The yarn is mechanically secured to the backing 302 by back loops 308 exposed on the underside of the carpet precursor. In this example the bcf yarn is made of polypropylene and the backing 302 is a woven fabric also made of polypropylene.

Figure 7b depicts a carpet product 310 made from the carpet precursor of Figure 7a. An extruded sheet 312 of polypropylene has been integrally fused to the carpet precursor 300. As shown in the figure the back loops 308 and portions of the backing have been heat bonded with the extruded sheet 312. As in the example of Figure 6a some voids or spaces may occur between the extruded sheet and carpet precursor.

During manufacture the back loops 308 may be partially melted so that individual fibers making up the bcf yarn are integrally fused with each other and with extruded sheet and primary backing 302. It has been observed experimentally that preheating of the carpet precursor before contacting it with the hot extruded sheet improves the mechanical stability of the resulting carpet product and secures the tufts and component yarn fibers to a sufficient degree that the carpet product can pass the VELCRO test.

Figure 7c depicts a carpet product 320 including an optional secondary backing 322. In this example, the secondary backing is laminated with the hot extruded sheet 312 and integrally fused with it.

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GRASS CARPET EXAMPLES

5 An apparatus substantially as shown and described in
c nnecti n with Figur 2 was empl y d t produce grass
carpet of the general structure shown and described in
connection with Figure 6b. The face yarn is fibrillated
film tape fiber made from polypropylene homopolymer with a
denier of 3800 and a fibrillation count of 13-17 per tape.
10 The primary backing is a 24x13 plain weave backing with 24
tapes in the warp direction per inch and 13 tapes in the
fill direction per inch. The tapes are made from
homopolymer polypropylene. The weight of the primary
backing is 3.3oz/square yard. The parameters of the
examples are set out in the following table.

15

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Example	Pre-heat Roll Temp. (°F)	Pre-heat Nip Pressure (PSI)	Extruded Film Thickness (mils)	Average Tuft Bind Strength (pounds)
A	400	60	10	3.84
B	400	60	10	5.10
C	400	80	10	5.18
D	430	80	10	6.25
E	440	60	5	4.51
F	440	60	10	5.72
G	440	60	10	5.87
H	440	80	10	4.35
I	450	80	10	5.02

The average tuft bind strength measurements were made
in accordance with ASTM D-1335.

Examples A-I were run at a line speed of about
10 feet per minute. The extruded melt temperature
was measured to be 600°F in the case of Example A and
625° in the case of Examples B through I. Examples
A, B and F employed a polypropylene homopolymer
having a nominal melt flow of 80. Examples C-E and
G-I employed a ethylene/propylene copolymer having a
nominal melt flow of 3.5.

Two comparative examples were run, which omitted
the preheating step. The results are reported below.

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Example	Extruded Film Thickness (mils)	Average Tuft Bind Strength (pounds)
J	10	1.65
K	10	1.46

5

These examples employing a polypropylene homopolymer having a nominal melt flow of 80 exhibited a lower tuft bind strength.

10

BCF LOOP PILE CARPET EXAMPLES

15

An apparatus substantially as shown and described in connection with Figure 2 was employed to produce bcf loop pile carpet of the general structure shown and described in connection with Figure 7b. The face yarn is a bulk continuous filament yarn made from polypropylene homopolymer. The yarn has a total denier of 2750 with 120 ends in the fiber bundle. The primary backing is as described above. The parameters of the examples are set out in the following table.

20

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Example	Pre-heat Roll Temp. (°F)	Pre-heat Nip Pressure (PSI)	Extruded Film Thickness (mils)	Average Tuft Bind Strength (pounds)
L	440	60	10	6.76
M	440	80	10	5.68
N	450	80	10	5.74

5

All three samples passed the VELCRO® test and had acceptable tuft bind strength as indicated. Example L employed a polypropylene homopolymer having a nominal melt flow of 80. Examples M and N employed an ethylene/propylene copolymer having a nominal melt flow of 3.5.

10

From the foregoing description, one of ordinary skill in the art can ascertain the essential characteristics of the present invention, and without departing from the spirit and scope thereof, can make changes and modifications of the disclosed techniques to adapt them to various uses and conditions. As such, these changes and modifications are properly within the scope of the range of equivalents of the following claims.

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WE CLAIM:

1. A method for manufacturing a carpet product comprising the steps of:

5 providing a carpet base having a primary backing penetrated by isotactic polymer yarn so that first portions of the yarn protrude from an upper side of the backing to form the pile of the carpet and so that second portions of the yarn are exposed
10 on the underside of the carpet base;

applying heat to the underside of the carpet base to thereby melt at least part of the exposed portions of the yarn;

15 extruding a heated sheet of isotactic polymer; and

continuously contacting the heated underside of the carpet base with the heated extruded sheet of polymer, thereby integrally fusing the second portions of the yarn and the extruded sheet.
20

2. The method of claim 1, wherein heat is applied to the underside of the carpet by contacting a heated surface against the underside of the carpet base immediately prior to contacting the heated
25 underside of the carpet base with the heated extruded sheet of polymer.

3. The method of claim 2, wherein the carpet base is passed between a heated plate and a
30 relatively cooler plate.

4. The method of claim 2, wherein the heated surface is the surface of a heated roller.

35 5. The method of claim 4, wherein the yarn is a polypropylene bulk continuous filament yarn and

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wherein the surface of the roller is maintained between 330°F and 650°F.

5 6. The method of claim 4, wherein the carpet base is pressed against the heated roller, and the surface of the roller is maintained between 400°F and 500°F.

10 7. The method of claim 6, wherein the yarn is a multi-fiber yarn and wherein the pressure and temperature of the heated roller are sufficient to deform, in cross-section, the second portions of the yarn.

15 8. The method of claim 4, wherein the carpet base is wrapped at least partially around the heated roller.

20 9. The method of claim 8, wherein the amount to which the carpet base is wrapped around the heated roller is varied to control the heating of the carpet base.

25 10. The method of claim 1, wherein the second portions of the yarn, the primary backing and the extruded sheet are integrally fused.

30 11. The method of claim 1, wherein the carpet is a loop pile carpet, wherein the yarn is a bulk continuous filament yarn made up of plural fibers, and wherein substantially all of the yarn fibers are secured in place by the heating of the carpet base and the contacting with the extruded sheet.

35 12. The method of claim 1, wherein the yarn, primary backing and extruded sheet are made of the

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same thermoplastic polymer.

13. The method of claim 12, wherein the extruded sheet is made of recycled portions of the carpet made by the process.

14. The method of claim 13, wherein the thermoplastic polymer is an isotactic polypropylene homopolymer; random impact or block copolymer; or terpolymer.

15. The method of claim 1, wherein the yarn, primary backing and extruded sheet are made of nylon.

16. The method of claim 1, wherein the extruded sheet includes an elastomer.

17. A method for manufacturing a carpet comprising:

tufting an isotactic polypropylene primary backing with a multi-fiber isotactic polypropylene yarn to form a carpet base with a portion of the yarn exposed on the underside of the carpet base;

contacting the underside of the carpet base along substantially its entire width against the cylindrical surface of a heated roller to thereby heat a contacted portion of the exposed yarn to a temperature above its melting point;

contacting the underside of the heated carpet base with a hot, extruded isotactic polypropylene sheet received from an extrusion die; and

moving the carpet base and extruded sheet against the surface of a casting roll so that extruded sheet contacts the casting roll.

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18. The method of claim 17, wherein the underside of the carpet base is at least partially wrapped around the surface of the heated roller which surface is maintained at a temperature between 330°F and 600°F.

19. A method for manufacturing a carpet comprising:

tufting a primary backing with crystalline thermoplastic polymer yarn to form a carpet base with a portion of the yarn exposed on the underside of the carpet base;

contacting the underside of the carpet base along substantially its entire width against the surface of a heated roller to thereby heat the exposed yarn to a temperature above the melting point of the crystalline thermoplastic polymer;

providing a sheet of crystalline thermoplastic polymer film;

heating the sheet of polymer film; and

pressing the heated polymer film against the heated underside of the carpet base to integrally fuse the sheet of polymer film with the carpet base.

20. The method of claim 19, wherein the sheet of polymer film is provided from a roll of previously extruded crystalline thermoplastic polymer film.

21. An apparatus for manufacturing a carpet comprising:

a source of carpet precursor having a primary backing interpenetrated by a face yarn wherein both the yarn and the primary backing are made of an isotactic thermoplastic polymer;

a heated roller for heating the underside of the carpet precursor substantially uniformly

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across its width;

an extruder for extruding an isotactic thermoplastic polymer sheet directly onto the heated underside of the carpet precursor; and

5 a casting roll against which the extruded sheet and heated carpet precursor are pressed.

22. The apparatus of claim 21, wherein the heated roller is heated by a circulating fluid in its interior.

23. The apparatus of claim 21, wherein the heated roller is pressed against the carpet precursor with sufficient pressure to compress yarn loops or knots on the underside of the carpet precursor.

24. The apparatus of claim 21, wherein the heated roller is heated so that its surface is maintained at a temperature above the melting point of the thermoplastic polymer.

25. The apparatus of claim 24, wherein a cylindrical surface of the heated roller is covered with a material which resists sticking.

26. The apparatus of claim 25, wherein the cylindrical surface of the heated roller is coated with teflon.

27. The method of claim 4, wherein the surface of the heated roller resists sticking of the carpet base to the heated roller.

28. A loop pile carpet comprising:
a polypropylene primary backing;
a polypropylene bulk continuous filament

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yarn made up of plural fibers, said yarn being tufted in said primary backing and having back loops on the underside of the primary backing; and

5 a sheet of polypropylene integrally fused with said back loops, so that substantially all the yarn fibers are secured in place.

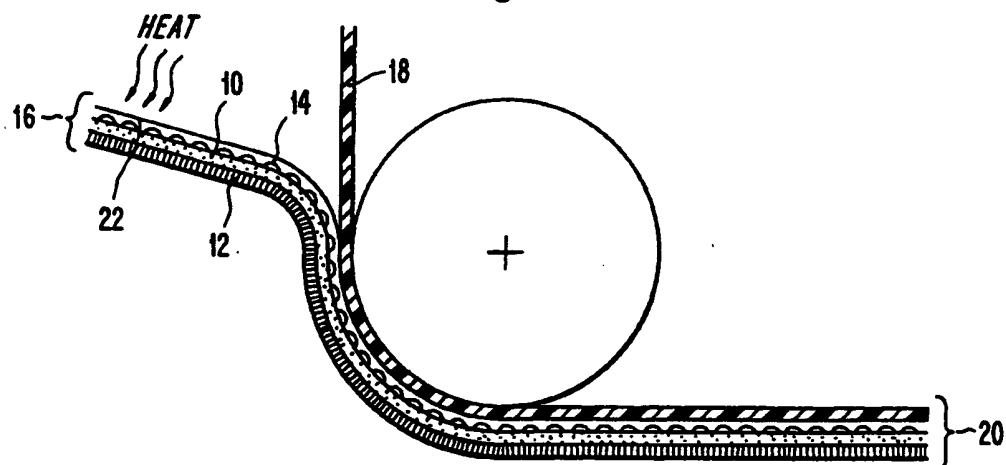
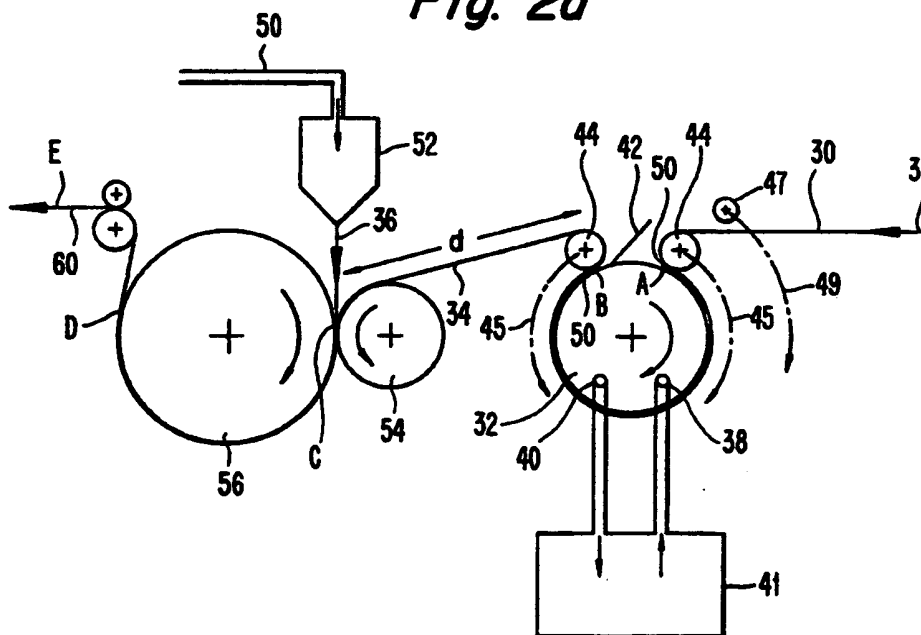
10 29. The carpet of claim 28, wherein the yarn back loops are compressed between the primary backing and the polypropylene sheet.

15 30. The carpet of claim 28, further comprising a secondary backing integrally fused to the polypropylene sheet.

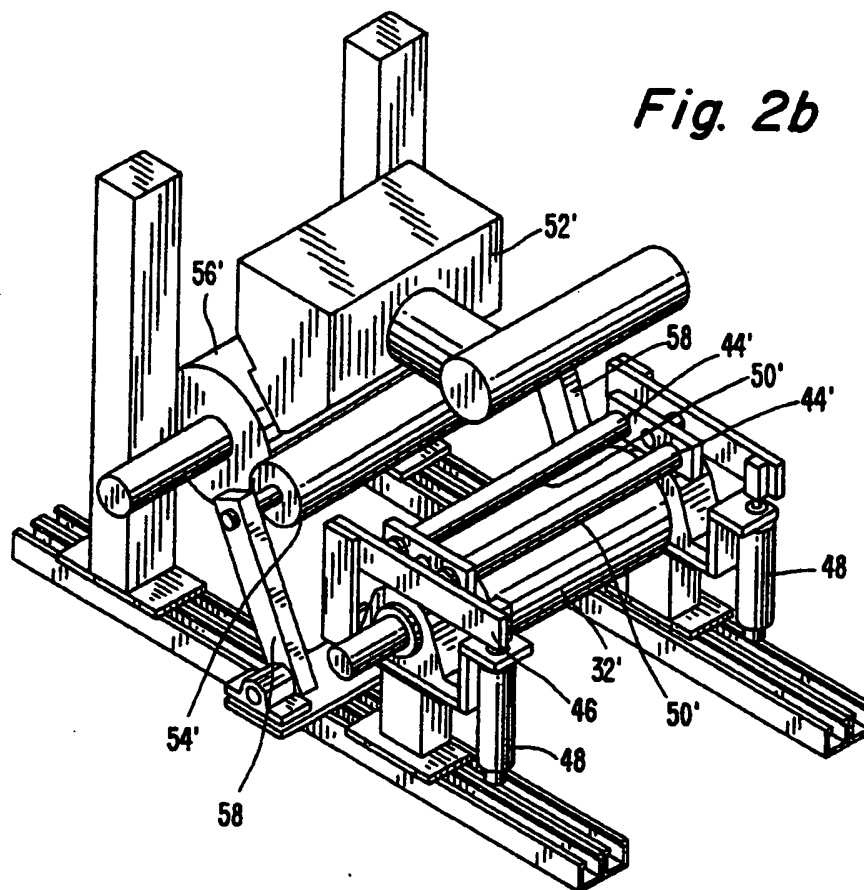
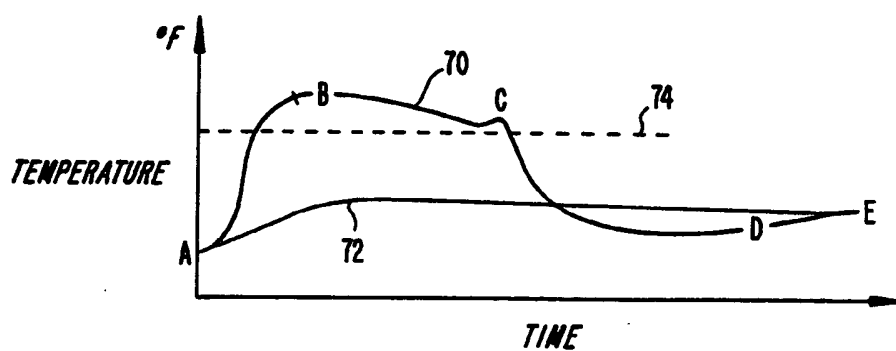
31. The carpet of claim 28, wherein the carpet has a tuft bind strength of at least 4 pounds.

20 32. The carpet of claim 28, wherein the sheet of polypropylene is integrally fused with both the back loops and the primary backing.

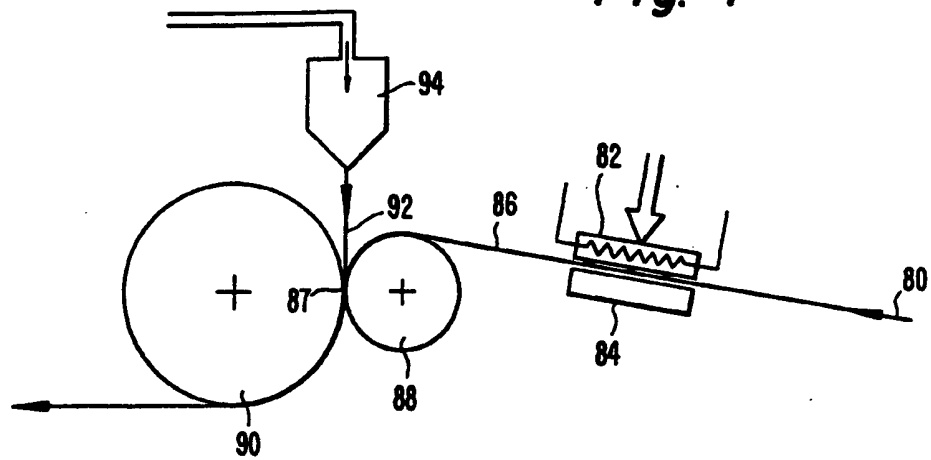
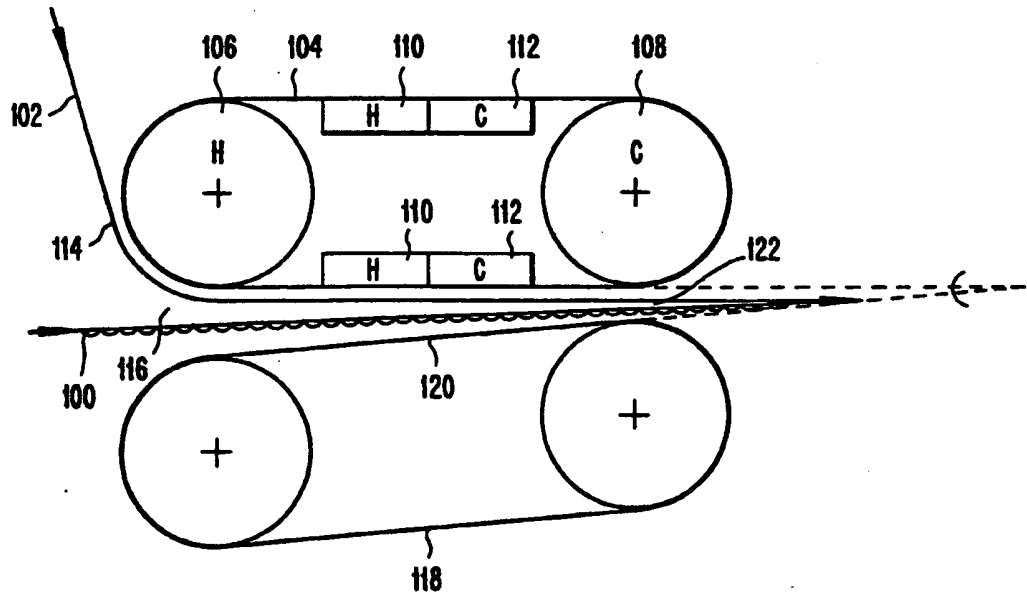
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Fig. 1**Fig. 2a**

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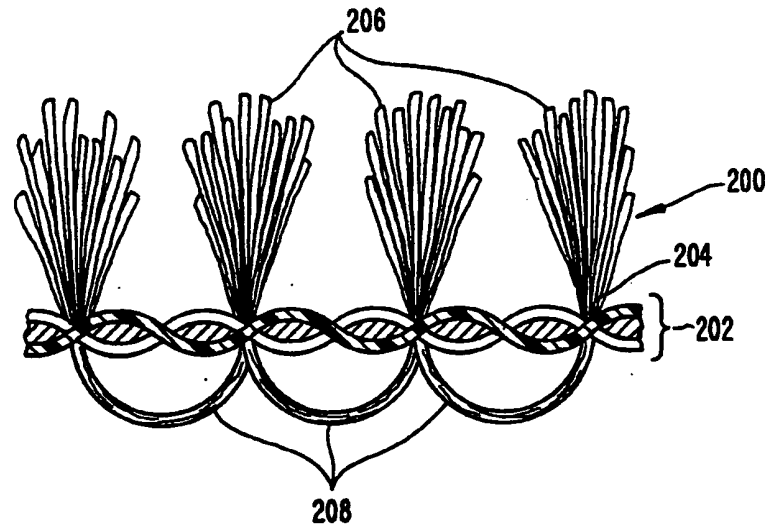
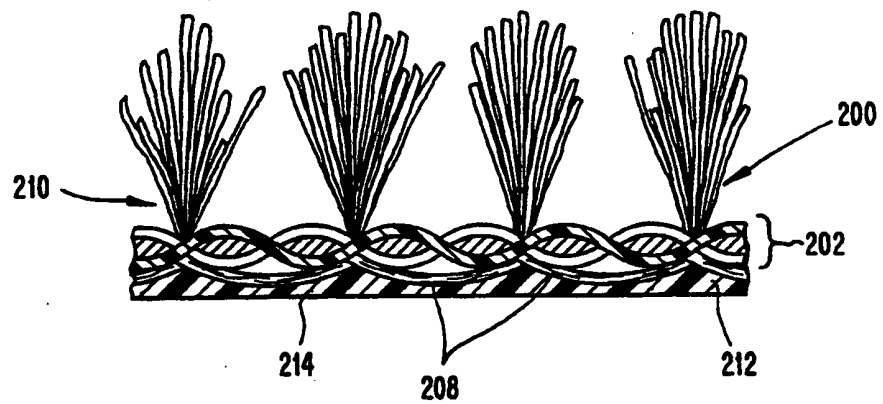
Fig. 2b*Fig. 3*

SUBSTITUTE SHEET (RULE 26)

Fig. 4*Fig. 5*

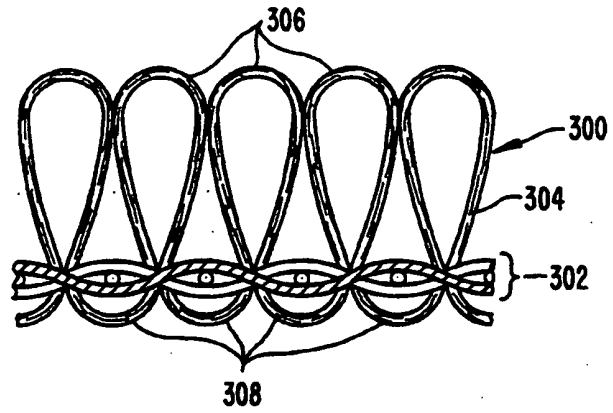
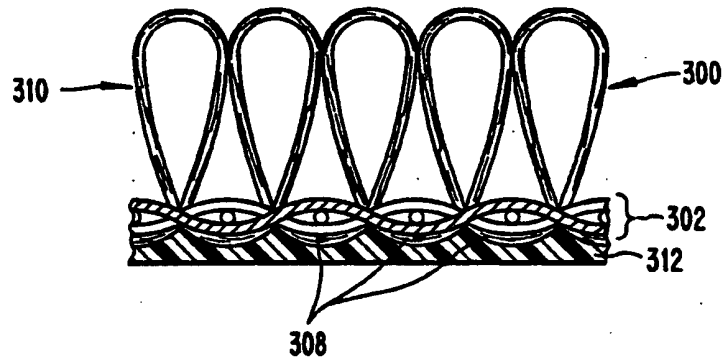
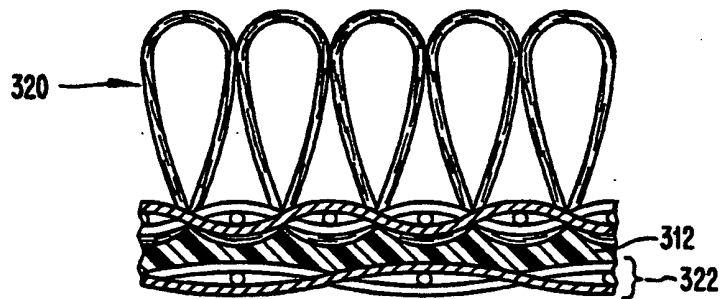
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Fig. 6a**Fig. 6b**

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Fig. 7a*Fig. 7b**Fig. 7c*

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/05531**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :D05C 15/00, 17/00

US CL :156/72, 244.11; 428/85

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 156/72, 244.11; 428/85

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS: carpet# and (((isotactic (p) polypropylene) (p) (pile or yarn or tuft#)) (p) ((isotactic (p) polypropylene) (p) (backing or scrim)))

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 3,537,946 (TRUAX ET AL) 03 November 1970, see whole document.	1-32
Y	US, A, 5,109,784 (LEPE-CISNEROS) 05 May, 1992, see whole document.	1, 10, 21-22
Y	US, A, 4,705,706 (AVERY) 10 November 1987, see whole document.	17-20, 24-26, 28-32
Y	US, A, 4,624, 878 (EVANS ET AL) 25 November 1986, see whole document.	5, 7, 12-15, 17-20, 23-26, 28-32
Y	US, A, 4,673,604 (FRAIN, III ET AL) 16 June 1987, see whole document.	12-20, 28-32
Y	US, A, 4,028,159 (NORRIS) 07 June 1977, see whole	13-15

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be part of particular relevance	X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	A	document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means		
P document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

23 JUNE 1995

Date of mailing of the international search report

03 AUG 1995

Name and mailing address of the ISA/US
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/05531

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 3,928,281 (UCHIGAKI ET AL) 23 December 1975, column 5, lines 31-32.	1-27
Y	US, A, 4,336,286 (TOMARIN) 22 June 1982, column 3, lines 25-28.	1-27
Y	US, A, 4,140,071 (GEE ET AL) 20 February 1979, column 1, lines 9-11; column 2, lines 4-13.	1-27
Y ^P	US, A, 5,380,574 (KATOH ET AL) 10 January 1995, column 6, lines 13-34.	1-32
Y ^P	US, A, 5,317,070 (BRANT ET AL) 31 May 1994, see whole document.	1-32
Y	US, A, 4,844,765 (REITH) 04 July 1989, see whole document.	19-20

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/05531

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a):

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐

The additional search fees were accompanied by the applicant's protest.

☒

No protest accompanied the payment of additional search fees.

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-27, drawn to a method and apparatus for making a carpet.

Group II, claim(s) 28-32, drawn to a loop pile carpet.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: claims in group I are clearly directed to a method/apparatus wherein heat and a thermoplastic polymer binder are explicitly used to fusion form a carpet. However, product claims of group II give no indication that such a heating step was ever used. The sheet of polypropylene which is "integrally fused" in group II could have been formed by solvent removal or some other process.